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Tech-Savvy on Board: Investigating the Impact of Board of Directors' IT Professional Experiences on Firms' IT Investment and Performance

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Abstract

Our study investigates whether having directors with IT professional experiences on board impacts a firm's IT investment growth and financial performance. We gather data from BoardEx, Compustat, and Harte-Hanks databases for S&P 1500 firms between 2011 and 2017. We include a rich set of controls and fixed effects in the analysis. We also employ a novel strategy to adjust for the remaining selection on unobservables. Our analysis shows that firms with tech-savvy directors have higher investment growth in different categories of IT including software, hardware, communication, and services. We also find these firms experience better performance measured by Tobin's Q. The findings highlight the importance of board of directors in driving IT investment growth and firm performance.

Keywords: Board of directors, IT professional experiences, IT investment, firm performance

Introduction

Businesses' investment in information technologies (IT) has been growing steadily over the past decade in the US. For example, the total IT investment is projected to be 2,070 billion dollars in 2022, which almost doubles the total IT investment of 1,230 billion dollars in 2012 (Forbes et al., 2021). Despite the increasing IT investment, there are noticeable variations in the return to IT investment (Ho et al., 2017; Saldanha et al., 2020; Steelman et al., 2019), probably because the outcomes of IT investment are affected by many organizational factors. Prior research primarily focuses on the roles of Chief Information Officers (CIO) and their relationships with other executives in influencing IT outcomes (e.g., Banker et al., 2011; Karahanna & Preston, 2013; Wu et al., 2015). Different from prior research, our study investigates how directors with IT professional experiences (hereinafter referred to as "tech-savvy directors") affect a firm's IT investment and performance.

We focus on board of directors for the following reasons. First, Boards can also exert major influences on firms' IT investment decisions. Executives of a firm might be the key decision-makers, but it is the board that holds the ultimate authority over important decisions (Benaroch & Chernobai, 2017; Yayla & Hu, 2014). IT investment may have significant impacts on the allocation of a firm's financial resources. For example, corporate IT assets can account for more than 50% of capital spending (Nolan & McFarlan, 2005). As a result, IT investment decisions may rise to the board level.

Second, as IT plays an increasingly important role in driving firm growth, it is likely that boards will engage in IT investment decisions to a greater degree. According to Deloitte's 2020 global technology leadership study, high-performing firms are nearly twice as likely to prioritize IT as an enabler to gain competitive advantages (Buchholz, 2020). There are suggestions that boards should closely examine the opportunities enabled by IT (Stiles & Taylor, 2001). Therefore, IT investment may become an important issue on boards' agenda.

Third, although IT investment may generate competitive advantages, the outcomes are highly uncertain due to the rapid obsolescence, technological complexity, and implementation challenges of IT (Dewan et al., 2007). Given the risks of IT investment, it is crucial to scrutinize the investment decisions. Boards have an obligation to review, approve, and monitor corporate plans, especially those that may impact the interests of shareholders (American Law Institute, 1994). As such, boards may have an important impact on IT investment decisions.

While boards may influence firms' IT investment, many board members may not have the necessary IT knowledge to participate in IT investment decisions. According to BoardEx, in 2019, only 8.1% of the newly appointed directors in S&P 1500 firms were taken by tech-savvy directors. Research in non-IT contexts shows that a board's ability to involve in relevant functional roles critically depends on the skills and knowledge of the board members (Carpenter & Westphal, 2001). For example, financial experts (e.g., bankers) on boards significantly affect corporate financial decisions (Güner et al., 2008). Likewise, tech-savvy directors may also impact corporate IT-related decisions.

To investigate the impact of tech-savvy directors on a firm's IT investment and financial performance, we construct a panel dataset covering S&P 1,500 firms between 2011 and 2017 from multiple sources, including the BoardEx, Compustat, and Harte-Hanks databases. We find that firms with tech-savvy directors on the board have a higher growth rate in IT investment, and the effect is significant in many different areas of IT vestment, including hardware, software, communication, and services. We also find these firms experience better firm performance measured by Tobin's Q.

Our study contributes to the literature on corporate IT governance. We highlight the important role of board of directors in IT investment. We show that directors' IT professional experiences have a sizable effect on firms' IT investment, which further impacts firms' financial performance. Our study also has important policy implications. Because tech-savvy directors increase the allocation of financial resources to IT, which further drives business growth, firms may actively search for directors who have IT professional experiences if they would like to leverage IT investment for better performance.

Literature Review

Our study joins the research that investigates corporate governance relating to IT activities (i.e., IT governance). Extant IT governance literature primarily focuses on IT executives and their relationships with CEOs or other executives. Despite the potential importance of boards in shaping IT investment decisions, much less attention has been paid to boards. In this section, we first summarize the IT governance literature on IT executives and then review the sparse literature on board of directors. We highlight our contribution to the literature by differentiating our study from existing research.

CIO and Corporate IT Governance

The role of CIOs has been widely examined in the IT governance literature. There are three streams of work in this literature. The first stream examines the impact of CIO characteristics on IT outcomes, including characteristics such as personality traits, educational level and background, job tenure, and professional experiences. For example, Li et al. (2006) find that CIOs who are more open and extroverted and have higher educational levels are more likely to use IT innovatively, which further leads to better firm performance. Khallaf and Majdalawieh (2012) find that long CIO tenure is associated with higher IT security performance because these CIOs are more experienced in IT and can make suggestions for improving existing IT-related organizational processes. The authors also find that CIOs with a degree in management (e.g., business, economy, and public administration) can strengthen corporate IT security performance because they have the managerial skills to effectively deal with IT security incidents. Sobol and Klein (2009) examine CIOs' professional experiences. They find that CIOs with IT professional experiences are associated with greater financial performance than those with only general managerial experiences.

The second stream of work is concerned with a debate regarding whether CIOs matter in corporate IT governance. For example, Gonzalez et al. (2019) find that there is a stereotype that CIOs are mere technological leaders who have the common traits and abilities of typical IT professionals and thus are not suited for important managerial roles. As such, CIOs' ability to influence IT decisions might be limited. Taylor and Vithayathil (2018) further argue that Chief Marketing Officers (CMO) may have greater power than CIOs in corporate IT decisions and consequently may impact firm performance to a greater degree. However, they do not find evidence that CMOs have greater impacts on firm performance than CIOs. There are also many studies showing the importance of CIOs in corporate IT governance. For example, Ranganathan and Jha (2008) argue that CIOs could enhance firms' IT management capabilities. They find that firms that have a CIO also have better financial performance. Zafar et al. (2016) show that firms with a CIO on their top management teams recover from security breaches more quickly. Li et al. (2021) show that having a CIO positively influences a firm's overall strategic direction and goals associated with cutting-edge technologies like artificial intelligence (AI).

The third stream of work investigates factors that impact the effectiveness of CIOs, including reporting structure, relationship with the CEO or TMT, power of authority, and personal factors. For example, Banker et al. (2011) find that the alignment between CIO reporting structure and firm strategy significantly impacts firm performance. Specifically, if a firm employs a product differentiation strategy, CIO reporting to the CEO is associated with better firm performance. In contrast, if a firm adopts a cost reduction strategy, CIO reporting to the Chief Financial Officer (CFO) is associated with better firm performance. Benlian and Haffke (2016) and Johnson and Lederer (2010) highlight the importance of partnership between CIO and CEO: a good relationship with mutual understanding enhances their collaboration and facilitates IT project implementation. Preston et al. (2008) and Chen et al. (2010) show that CIOs should be delegated with sufficient authority to make strategic decisions to fulfill their IT leader roles more effectively. Chen et al. (2021) similarly argue that CIOs' authority, relationships with the TMT, knowledge of IT, and political savvy impact their ability to sell IT-related issues in corporate decision-making.

Board of Directors and Corporate IT Governance

There is a small literature on how board of directors affects corporate IT governance. Our reading of the literature reveals three streams of work. The first stream focuses on the impacts of board committees on corporate IT governance. A board committee is a small group of people led by directors to deal with specific issues requiring specialized expertise. Board committees may have important impacts on organizational outcomes (Klein, 1998). For example, Higgs et al. (2016) find that having an IT board committee is associated with a greater number of reported security breaches because an IT committee improves a firm's capacity to detect security breaches. They also find that an IT committee can mitigate the negative impacts of security breaches (e.g., negative abnormal stock return). Turel et al. (2019) similarly show that having an IT board committee helps a firm use IT more effectively, which further leads to better financial performance.

The second stream of work investigates the composition of board of directors. Dimensions such as board size, board independence, director affiliation, and board interlock are examined. For example, Jewer and McKay (2012) find that board size has a negative impact on corporate IT governance because a large board may reduce board members' ability to work together. Abebe and Simpson (2015) find that board independence (i.e., the separation between chairman and CEO) increases the effectiveness of crisis management. Pan et al. (2016) show that in the IT industry, boards with a higher proportion of outside directors are more efficient in monitoring executives and more active in offering options for corporate strategy development. A few studies examine board interlock, that is, a firm's board member also serves as a director for other firms. For example, Howard et al. (2017) argue that firms might gain access to other firms' technological knowledge through board interlock. Cheng et al. (2021) show that a firm's investment in IT is significantly affected by the IT investment of its interlocked counterparts.

The third stream focuses on the impacts of board members' characteristics. For example, Simionescu et al. (2021) find that gender diversity of the board impacts a firm's accounting and market-based performance in the IT industry. Horváth and Spirollari (2012) show that the age of directors matters in corporate governance. Specifically, younger directors are more willing to bear more risks in making major decisions to improve a firm's future prospects. Carpenter and Westphal (2001) suggest that the expertise possessed by outside directors affects their involvement in monitoring and strategic advising. Yayla and Hu (2014) show that directors' experiences in IT have a positive impact on firm performance, and the effect is larger for firms in IT-intensive industries.

Our study contributes to the third stream of board IT governance research that examines the characteristics of board members. Specifically, we explore the impact of directors' IT professional experience on firms' IT investment and financial performance. Through this investigation, we highlight the importance of the board of directors in matters pertaining to IT investment, which are often neglected in previous studies. Furthermore, our research contributes to the understanding of how directors with relevant IT expertise impact decision-making regarding IT investment, ultimately leading to superior performance outcomes.

Methodology

Data and Sample

We construct a rich panel dataset from several sources. We start by drawing an initial sample from ExecuComp, which covers 2,369 firms in the S&P 1500 index between 2011 and 2017.

Director Information and Background

We obtain information about the sample firms' boards of directors and background of board members from the BoardEx database. BoardEx provides exhaustive and high-quality data for over 20,000 companies and is widely used in board research (Chu & Davis, 2016; Haislip et al., 2021). We link BoardEx to our sample with the help of the linking suite provided by the Wharton Research Data Services (WRDS). The linking suite assigns a score from 1 to 10 to each pair of matching firms. The score indicates the credibility of matching, with one being the most credible and ten being the least. We only consider the matches whose credibility score is smaller than three. After the match, we retrieve the roster of directors for each firm and their job histories from BoardEx.

IT Infrastructure and Investment

We obtain the amount of IT investment and the number of IT staff from the Harte-Hanks Computer Intelligence database.[1] This database provides site-level IT infrastructure data and is regarded as a reliable source of information (Bloom et al., 2014; Cheng et al., 2021; Tambe & Hitt, 2012). Harte-Hanks has three levels of business sites: branches, divisional headquarters, and ultimate headquarters. We aggregate the amount of IT investment and the number of IT staff from site-level to enterprise-level for all firms. To link the aggregated data to our sample, we first conduct a fuzzy match based on company names between Harte-Hanks and BoardEx. The fuzzy matching retains as many potential pairs of matches as possible. We then manually verify each match by checking the firms' names, industries, geographic locations, and other fields available in both data sources.

At last, we supplement our data with firm characteristics and corporate financial performance from Compustat. The final sample consists of 7,573 observations from 1,760 firms. The unit of analysis in our study is each firm-year pair.

Variables

Dependent Variable

Our dependent variable is firm-level IT investment growth. Specifically, we use $\Delta ln(ITINV_{it})$ to approximate the IT investment growth of firm i at year t, where $\Delta ln(ITINV_{it})=ln(ITINV_{i,t})-ln(ITINV_{i,t-1})$.

In addition to the total IT investment, Harte-Hanks provides a detailed decomposition of IT investment into four categories: software, hardware, communication, and services. Software budget is the spending on software purchased from third parties, including packaged software delivered on CD and installed by the

[1] Harte-Hanks provides the number of IT staff in intervals (e.g., "50 to 99"). Following prior studies (e.g. Dranove, 2014), we transform the intervals to continuous values by taking the midpoint of each interval (e.g., 74 for the interval of "50 to 99").

firm, software as a service (SaaS) hosted on a cloud server, or custom-developed software for the firm by third-party contractors. Hardware budget is the expenditures in purchasing or maintaining hardware equipment such as personal computers, servers, storage, and peripherals. Communication budget is the spending on network equipment that supports communication needs. Services budget is the expenditures in project-based consulting or system integration services provided by third-party vendors to the firms. The services are offered mainly by IT outsourcing vendors on a contractual basis.

We also investigate the further impact of tech-savvy directors on firms' financial performance. We use two measures for firm performance: return on assets (RoA) and Tobin's Q. These are widely used in the IS literature (Chae et al., 2014; Mithas & Rust, 2016; Yayla & Hu, 2014). RoA is the ratio of net income to total assets, which indicates how efficiently a firm can generate profits from its total assets. Tobin's Q is calculated as the market value of a firm divided by its assets' replacement costs, which captures a firm's growth opportunities. The two measures are denoted by RoA_{it} and $TobinsQ_{it}$, respectively, where i indices the firms and t indicates year.

Independent Variable

Following prior research, we consider a director to be tech-savvy if he or she has experiences in positions as Chief Information Officer (CIO), Chief Technology Officer (CTO), or other executives with an equivalent title (e.g., Vice President of IT) (Héroux & Fortin, 2018).[2,3] We create a binary variable ToB_d_{it} to indicate whether firm i has tech-savvy on its board at year t. We also create a continuous variable ToB_n_{it} to indicate the number of tech-savvy directors on firm i's board at year t to ensure the robustness of our findings.

Control Variable

We include a set of control variables to account for the impacts of firm size, industry of firms, and the importance of IT to firms. Specifically, we use a firm's total assets, sales, and number of employees to control for firm size, as these are the most common measures of it (Yayla & Hu, 2014). We include these variables as controls because they are likely to have impact on firm IT investment. For example, larger firms tend to have more investment. We also control for industry of the firms because the industry to which a firm belongs may impact its IT investment (Li et al., 2021). For example, firms in the IT industry may have larger IT investment. The importance that a firm attaches to IT also impacts its IT investment, but it is unobservable. We use whether the firm has a CIO and the IT department size of the firm as two proxies for the importance of IT to a firm. The intuition is that a firm will likely have a CIO and a large IT department if IT is important to the firm. The variables in our analysis are summarized in Table 1.

Variable	Definition	Source	Mean	S.D.
	Dependent Variables			
$\Delta ln(ITINV_{it})$	Growth rate of firm i's total IT investment at year t.	Harte-Hanks	0.50	1.04
$\Delta ln(SWINV_{it})$	Growth rate of firm i's IT investment in software at year t.		0.40	1.10
$\Delta ln(HWINV_{it})$	Growth rate of firm i's IT investment in hardware at year t.		0.39	1.10
$\Delta ln(CMINV_{it})$	Growth rate of firm i's IT investment in communication at year t.		0.41	1.12

[2] The titles include Chief Information Officer, Chief Technology Officer, Vice President of Technology, Vice President of Information Technology, Vice President of Information Services, Vice President of Technology Solutions, Senior Vice President of Science & Technology, and Vice President of Technology & Engineering.

[3] One may argue that a director can be tech-savvy without any IT professional experiences. For example, a director may become tech-savvy through education. However, prior research suggests that IT knowledge required in managerial decisions is mostly tacit, which can only be learned through relevant professional experiences rather than from textbooks (Erden et al., 2008).

$\Delta ln(SVINV_{it})$	Growth rate of firm *i*'s IT investment in service at year *t*.		0.49	1.05
RoA_{it}	The return on assets of firm *i* at year *t*, calculated as the net income divided by the total assets.	Compustat	0.03	0.14
$TobinsQ_{it}$	A measure of performance of firm *i* at year *t*, calculated as the market value of a firm divided by its assets' replacement costs.		2.01	1.53
	Independent Variables			
ToB_d_{it}	Whether firm *i* has tech-savvy directors on its board at year *t*.	BoardEx	0.20	0.40
ToB_n_{it}	The number of tech-savvy directors on firm *i*'s board at year *t*.		0.24	0.52
	Control Variables			
CIO_{it}	Whether firm *i* has a CIO at year *t*.	ExecuComp	0.08	0.27
$ln(Assets_{it})$	Log transformed total assets of firm *i* at year *t*.	Compustat	14.90	1.80
$ln(Sales_{it})$	Log transformed sales of firm *i* at year *t*.		14.30	1.80
$ln(Emp_{it})$	Log transformed number of employees of firm *i* at year *t*.		8.30	1.88
$Industry_i$	The industry to which firm *i* belongs[4].			
$ITDeptSize_{it}$	IT department size of firm *i* at year *t*, calculated as the proportion of IT staff to total staff.	Harte-Hanks	0.07	0.35
Note: we add one to the relevant variables before we log-transform them.				

Table 1. Variables Definitions, Sources, and Summary Statistics

Empirical Strategies

The main challenge of identification in our study is the potential endogeneity of tech-savvy on board. In this section, we discuss some possible issues and remedies for them.

First, there could be macroeconomic trends, such as the development of digital economy, that simultaneously promote firms' digital transformation and the supply of directors who have IT professional experiences. Because digital transformations may require significant investment in IT, it could lead to a spurious positive correlation between tech-savvy directors on board and IT investment growth.

Second, firms in some industries may have a preference for directors who have IT professional experiences. For example, IT firms may favor people who have IT backgrounds, even for non-technological positions. Thus, these firms may also favor directors who have IT professional experiences. Since IT firms tend to have greater IT investment growth than firms in other industries, this may result in a spurious positive correlation between tech-savvy directors and IT investment growth.

Third, because larger firms typically have more directors on their boards, the likelihood of having tech-savvy directors on board increases. Large firms are also more likely to have the financial resources to quickly grow their IT assets. This may generate a positive correlation between tech-savvy directors on the board and IT investment growth. Alternatively, we may also argue that large firms may in general experience slower IT investment growth due to the large IT investment base. This will instead generate a negative correlation between tech-savvy on board and IT investment growth.

[4] There are 10 major industries in the SIC system, see https://www.osha.gov/data/sic-manual.

Lastly, a firm may view IT as an important driver for operational efficiency and strategic advantage. The firm may increase IT investment over time and, at the same time, recruit tech-savvy directors to its board. In this case, both IT investment growth and tech-savvy directors on the board are driven by the importance of IT to the firm, which may generate a positive correlation between tech-savvy directors and IT investment growth.

We address these issues in three ways. First, for the endogeneity issues due to selection on observables, we include the observables as controls in the analysis. For example, we control for firm size by including sales, number of employees, and total assets of a firm. Second, to account for the impact of unobserved macroeconomic trends and industrial factors, we include time and industry fixed effects in the regression models. We use the presence of CIO and the relative size of the IT department to proxy for the importance of IT to a firm. Third, we apply a method developed by Oster (2019) to diagnose to what extent our results are affected by omitted variable bias, especially those time-variant confounders (e.g., the importance of IT to a firm), and adjust for the bias by generating bias-adjusted estimates.

Regression Models and Results

IT Investment Growth

To assess how tech-savvy directors on board influences a firm's IT investment growth, we estimate the following fixed-effects model:

$$\Delta\ln(Investment_{it}) = \beta_0 + \beta_1 ToB_{it} + \boldsymbol{\gamma X_{it}} + Industry_i + Year_t + \varepsilon_{it} \tag{1}$$

Where $\Delta ln(Investment_{it})$ approximates the IT investment growth rate of firm i at year t. We examine the IT investment growth rate in these categories: total IT investment, software, hardware, communication, and services.

ToB_{it} is the focal variable, tech-savvy on board. We measure it using both a binary and a continuous variable. ToB_d_{it} is the binary variable indicating the presence of tech-savvy directors on board. It equals one if firm i has at least one tech-savvy director on board at year t. ToB_n_{it} is the continuous variable, which indicates the number of tech-savvy directors on firm i's board at year t.

$\boldsymbol{X_{it}}$ is a vector of control variables, including firm size, whether firm i has a CIO, and firm i's IT department size measured by the proportion of IT staff to total staff. $Industry_i$ and $Year_t$ are industry and year fixed-effects, respectively. The coefficient β_1 is the effect of interest, which captures the impact of tech-savvy on board on IT investment growth.

Table 2 shows the results. For all models, standard errors are clustered at the firm level to allow the investment growth rate of a firm to be serially correlated. Column (1) of Table 2 shows that the presence of tech-savvy directors on board is associated with higher IT investment growth rate. Columns (2) to (5) show that the positive association is consistent across all categories of IT investment (i.e., software investment, hardware investment, communication investment, and services investment). The results are similar when tech-savvy on board is measured by the number of tech-savvy directors, as shown in columns (6) to (10).

Firm Financial Performance

We also examine whether tech-savvy on board further impacts a firm's financial performance. We use the same specification to estimate the effect.

$$Performance_{it} = \beta_0 + \beta_1 ToB_{it} + \boldsymbol{\gamma X_{it}} + Industry_i + Year_t + \varepsilon_{it} \tag{2}$$

Where $Performance_{it}$ is the financial performance of firm i at year t, measured by RoA and Tobin's Q. We examine firm financial performance with a lag of up to three years (i.e., t+1, t+2, t+3) to capture the long-term impacts of tech-savvy on board.

The results of the regression models are summarized in Table 3. Columns (1) to (3) and (7) to (9) in Table 3 show that a firm's RoA is not affected by the presence or the number of directors who have IT professional experiences on board. However, the results in columns (4) to (6) and (10) to (12) show that there is a significant association between tech-savvy directors on board and firm performance measured by Tobin's Q.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	△ln(ITINV)	△ln(SWINV)	△ln(HWINV)	△ln(CMINV)	△ln(SVINV)	△ln(ITINV)	△ln(SWINV)	△ln(HWINV)	△ln(CMINV)	△ln(SVINV)
ToB_d	0.064** (0.021)	0.070** (0.022)	0.069** (0.022)	0.069** (0.024)	0.059** (0.021)					
ToB_n						0.049** (0.016)	0.054** (0.017)	0.054** (0.016)	0.056** (0.018)	0.044** (0.016)
CIO	-0.022 (0.028)	-0.021 (0.027)	-0.049 (0.029)	-0.035 (0.029)	-0.030 (0.028)	-0.022 (0.028)	-0.021 (0.027)	-0.048 (0.029)	-0.035 (0.029)	-0.029 (0.028)
lnat	0.002 (0.011)	-0.004 (0.015)	-0.006 (0.014)	0.028* (0.014)	-0.003 (0.014)	0.002 (0.011)	-0.004 (0.015)	-0.006 (0.014)	0.028* (0.014)	-0.003 (0.015)
lnemp	-0.040** (0.009)	-0.039** (0.010)	-0.047** (0.010)	-0.048** (0.010)	-0.043** (0.010)	-0.039*** (0.009)	-0.039*** (0.010)	-0.047*** (0.010)	-0.047*** (0.010)	-0.043*** (0.010)
lnsale	0.048** (0.013)	0.059** (0.021)	0.063** (0.019)	0.031 (0.019)	0.057** (0.020)	0.048*** (0.013)	0.059** (0.021)	0.063** (0.019)	0.031 (0.019)	0.057** (0.020)
ITDeptSize	0.0378 (0.021)	0.067** (0.022)	0.050* (0.021)	0.025 (0.022)	0.020 (0.021)	0.038 (0.021)	0.067** (0.023)	0.050* (0.021)	0.025 (0.022)	0.020 (0.021)
Industry	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	7,573	7,573	7,573	7,573	7,573	7,573	7,573	7,573	7,573	7,573
R-sq	0.314	0.305	0.324	0.288	0.314	0.314	0.305	0.324	0.288	0.314

* p < 0.05, ** p < 0.01, and *** p < 0.001.

Table 2. Impact of Tech-Savvy on Board on IT Investment Growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	RoA_{t+1}	RoA_{t+2}	RoA_{t+3}	Tobin's Q_{t+1}	Tobin's Q_{t+2}	Tobin's Q_{t+3}	RoA_{t+1}	RoA_{t+2}	RoA_{t+3}	Tobin's Q_{t+1}	Tobin's Q_{t+2}	Tobin's Q_{t+3}
ToB_d	-0.006 (0.005)	-0.002 (0.005)	-0.001 (0.006)	0.215** (0.078)	0.254** (0.086)	0.264** (0.097)						
ToB_n							-0.003 (0.004)	-0.001 (0.004)	-0.001 (0.004)	0.183** (0.058)	0.210** (0.065)	0.212** (0.074)
CIO	-0.002 (0.006)	0.002 (0.005)	0.001 (0.006)	-0.005 (0.106)	0.006 (0.122)	-0.041 (0.13)	-0.002 (0.006)	0.002 (0.005)	0.001 (0.006)	-0.004 (0.105)	0.008 (0.121)	-0.038 (0.130)
lnat	-0.023 *** (0.004)	-0.023 *** (0.004)	-0.021 *** (0.005)	-0.277 *** (0.047)	-0.266 *** (0.052)	-0.253 *** (0.053)	-0.023 *** (0.004)	-0.023 *** (0.004)	-0.021 *** (0.005)	-0.277 *** (0.047)	-0.266 *** (0.052)	-0.253 *** (0.053)
lnemp	-0.005 (0.003)	-0.004 (0.003)	-0.001 (0.003)	-0.051 (0.035)	-0.034 (0.036)	-0.016 (0.038)	-0.005 (0.003)	-0.004 (0.003)	-0.001 (0.003)	-0.051 (0.035)	-0.034 (0.036)	-0.015 (0.038)
lnsale	0.041 *** (0.006)	0.039 *** (0.006)	0.034 *** (0.008)	0.185 *** (0.044)	0.157 ** (0.05)	0.142 ** (0.05)	0.041 *** (0.006)	0.039 *** (0.006)	0.034 *** (0.008)	0.185 *** (0.044)	0.157 ** (0.050)	0.142 ** (0.050)
ITDeptSize	-0.003 (0.003)	-0.004 (0.002)	-0.003 (0.004)	-0.119* (0.060)	-0.117 (0.062)	-0.101 (0.07)	-0.003 (0.003)	-0.004 (0.002)	-0.003 (0.004)	-0.118* (0.060)	-0.116 (0.061)	-0.100 (0.069)
Industry	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	9,004	8,565	7,034	8,993	8,551	7,015	9,004	8,565	7,034	8,993	8,551	7,015
R-sq	0.111	0.115	0.111	0.118	0.113	0.112	0.111	0.115	0.111	0.118	0.114	0.112

* $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Table 3. Impact of Tech-Savvy on Board on Firm Performance

Adjusting for Selection on Unobservables

Although our OLS specifications include a rich set of controls (e.g., firm size, CIO presence, relative size of IT department) and fixed effects (e.g., year and industry) to address endogeneity issues due to selection on both observables and unobservables, one might still be concerned that (a) there are time-variant unobservables that cannot be accounted for by the fixed effects, and (b) our controls may be incomplete proxies for these time-variant confounders (i.e., the importance of IT to a firm). To investigate the extent to which our results are affected by selection on unobservables, we employ a method proposed by Altonji et al. (2005) and expanded by Oster (2019).

The method evaluates the robustness of results to omitted variable bias by examining coefficient movements after the inclusion of observed controls. The intuition is that changes in the coefficients after adding relevant observed controls are informative of bias arising from unobserved variables not included in the model. For example, if a coefficient remains stable after the inclusion of relevant observed controls, it means that omitted variable bias might be limited. However, if the coefficient changes significantly, it suggests that selection bias may be an issue. Oster's method has been increasingly used in the economics literature. Some notable examples are Galor and Özak (2016), Dippel and Heblich (2021), and Finkelstein et al. (2021).

In our study, the existence of a CIO and the IT department size might be informative of the unobservable IT importance to a firm. Having a CIO or large IT department means that the firm allocates considerable human and financial resources to IT. It is plausible that these observable controls are correlated with the importance of IT to a firm. Therefore, we use these observable controls to diagnose the potential selection on unobservables.

The method quantifies the robustness of results to omitted variable bias in two different ways. The first one involves calculating a value δ, which serves as an indication of the extent to which unobserved variables must be relatively more important to observed variables to explain away the effect. A value of δ =1 , for example, would suggest that the unobservables need to be at least as important as the observables to produce an effect of zero. A larger value of δ is desired for the results to be robust to omitted variable bias. A second way is to calculate a consistent estimate of the bias-adjusted causal effect using a given value of δ (e.g., setting $\delta = 1$). Both ways require researchers to assume a value of R_{max}, a value for the R-squared from a hypothetical regression controlling for both observed and unobserved confounders. Oster (2019) suggests the value of R_{max} to be equal to 1.25 times of the R-squared from a regression with only the observed controls (denoted as $\tilde{R}$). We report the results for IT investment growth and firm performance in Table 4 and Table 5, respectively.

Column (1) of Table 4 shows that the estimate of δ for IT investment growth is 48.8, which means the unobserved factor (i.e., the importance of IT to a firm) has to be 48.8 times as important as the observables (i.e., CIO presence and IT department size) to produce a treatment effect of zero. According to Altonji et al. (2005) and Oster (2019), results with a δ above 1, can be viewed as robust to omitted variable bias. Our δ here is far beyond the suggested threshold of 1. Columns (2) to (5) of Table 4 show that the estimates of δ for sub-categories of IT investment are also large. Although the estimates of δ in Table 5 are not as large, they are all sufficiently large to be above the threshold of 1. Table 4 shows that the bias-adjusted effects on IT investment growth are quite close to the OLS coefficients, and Table 5 shows that the bias-adjusted effects of tech-savvy on board on Tobin's Q are smaller than the OLS coefficients, but these effects are still substantial.

	(1)	(2)	(3)	(4)	(5)
	$\Delta ln(ITINV_{it})$	$\Delta ln(SWINV_{it})$	$\Delta ln(HWINV_{it})$	$\Delta ln(CMINV_{it})$	$\Delta ln(SVINV_{it})$
ToB_d	0.064** (0.021)	0.070** (0.022)	0.069** (0.022)	0.069** (0.024)	0.0593** (0.0209)
Bias-adjusted *ToB_d* (δ=1)	0.0630	0.070	0.067	0.066	0.058
δ	48.8	122.6	23.9	17.2	43.2

ToB_n	0.049** (0.016)	0.054** (0.017)	0.054** (0.016)	0.056** (0.018)	0.044** (0.016)
Bias-adjusted *ToB_n* (δ=1)	0.048	0.054	0.051	0.054	0.043
δ	41.3	159.8	21.1	16.3	36.3
* p < 0.05, ** p < 0.01, and *** p < 0.001.					

Table 4. Bias-Adjusted Results of IT Investment Growth

	(1)	(2)	(3)
	Tobin's Q_{t+1}	Tobin's Q_{t+2}	Tobin's Q_{t+3}
ToB_d	0.215** (0.0776)	0.254** (0.0864)	0.264** (0.0969)
Bias-adjusted *ToB_d* (δ=1)	0.164	0.192	0.210
δ	3.7	3.6	4.2
ToB_n	0.183** (0.0580)	0.210** (0.0648)	0.212** (0.0743)
Bias-adjusted *ToB_n* (δ=1)	0.143	0.163	0.171
δ	3.9	3.8	4.4
* p < 0.05, ** p < 0.01, and *** p < 0.001.			

Table 5. Bias-Adjusted Results of Firm Performance

Discussion

Findings

The coefficients in Table 2 show that, on average, firms with at least one tech-savvy director on board increase IT investment 6.4% faster than those without. Among the four categories of IT investment, tech-savvy on board has the largest impact on software investment growth (7.0%), followed by the categories of communication (6.9%), hardware (6.9%), and services (5.9%).

Although tech-savvy on board has a consistent effect on all types of IT investment growth, its impact on firm performance is inconclusive. We find a significant impact on Tobin's Q but not RoA. A reason could be that although RoA and Tobin's Q are both metrics of firm performance, they capture different aspects of performance. RoA focuses more on operational efficiency and is concerned with a firm's past accounting performance. In contrast, Tobin's Q focuses more on the opportunities of a firm and is concerned with the future prospects of a firm (Tanriverdi, 2006). Given this difference, our findings might suggest IT investment contributes more to a firm's growth potential than to its operational efficiency. It can also be seen that in Table 3, the coefficient of *ToB_d* becomes progressively larger when we look at Tobin's Q further in the future (i.e., from 0.215 to 0.264). The effect size of *ToB_d* is non-negligible, because the average Tobin's Q of all firms is 2.006 only (see Table 1), which means having tech-savvy directors on board would increase the Tobin's Q by 10.7% - 13.2% for an "average" firm. The coefficients are slightly smaller when we look at the impact of the number of tech-savvy directors on board (i.e., *ToB_n*), but still remain significant in all models for IT investment growth and Tobin's Q.

We acknowledge that our study may suffer from potential endogeneity issues due to the possibility of omitted viable bias. For example, there may be firm characteristics, industrial characteristics, macroeconomic trends, and other time-varying confounders that may affect both tech-savvy on board and firm IT investment. Our study takes three steps to deal with the endogeneity issues. First, we include a rich set of control variables in the analysis to account for observed confounders. Second, we include year and industry fixed effects as well as proxies for the importance of IT to firms to account for unobserved confounders. Third, we use a method developed by Oster (2019) to adjust for selection on the remaining unobservables.

Table 4 shows that the OLS results of IT investment growth are reassuring, as the bias-adjusted coefficients remain almost unchanged. Therefore, the importance of IT is not likely to be a confounder in the analysis of IT investment growth. However, Table 5 shows that the bias-adjusted effects for Tobin's Q are slightly smaller than the OLS results, which suggests that OLS overestimates the performance impact of tech-savvy on board due to the omitted variable bias. Indeed, if the importance of IT to a firm is the unobserved confounder in the analysis of firm performance, it could result in overestimation of the effect of tech-savvy on board, as the importance of IT to a firm is positively correlated with both firm performance and the presence of tech-savvy directors on board.

In summary, we find that tech-savvy on board increases IT investment growth and contributes to firm performance in terms of future growth. The results of applying Oster's method suggest that our findings are not likely to suffer from severe endogeneity issues due to selection on unobservables.

Theoretical and Practical Implications

Our study has both theoretical and practical implications. Theoretically, we contribute to the literature on board of directors and IT governance. Although board of directors are suggested to have significant influence on corporate decisions (Benaroch & Chernobai, 2017; Yayla & Hu, 2014), it has gained little attention in the IT governance research. Differing from prior research on IT governance that primarily focuses on CIOs, we highlight the role of board directors by showing that they may also exert significant impacts on firms' IT investment.

Practically, our findings provide potentially important implications for firms, IT managers, and investors. We show that directors' IT professional experiences make a difference in firms' IT investment growth and having tech-savvy directors on board generates better firm performance measured by Tobin's Q. Therefore, firms can modify the configuration of their board by incorporating individuals with a technological background in order to enhance their investment in IT and trigger growth in their performance. In specific instances, firms may opt to elevate their IT executives to board membership. In light of our findings, IT executives themselves are encouraged to pursue board membership as a means of capitalizing upon their IT expertise. Further, investors would be well-advised to use the board members' IT expertise as a gauge for evaluating the future potential of a company's IT governance.

Limitations and Future Research

Our study may have several limitations. First, the current study adopts a narrow definition of "tech-savvy" directors, restricting their categorization to those having professional experience in IT. However, it is possible that other educational or vocational experiences may have provided them with relevant IT knowledge and expertise. As such, future studies may use broader definitions of tech-savvy directors so that a more complete understanding of the relationships between tech-savvy directors, IT investment growth, and firm performance may be gleaned. Second, our data range from 2011 to 2017, which is not up to date. However, we believe that the findings may still be relevant to current industry trends because the role of directors in IT governance is expected to be more prominent as the importance of IT continues to grow. Future research may consider conducting follow-up studies using more recent data. Third, although we show that having tech-savvy directors on board increases IT investment growth, it is unclear what mechanisms drive this effect. Investigating the underlying mechanisms might be a fruitful direction for future research. Fourth, we acknowledge the limitation of the Oster's method. The Oster's method is based on the assumption that the observed controls are informative of the unobserved confounders. It is possible that there are other unobservables that are not informed by our observed controls (i.e., CIO presence and

IT department size). Future research can consider other research designs (e.g., instrumental variable approach) to generate converging evidence.

Conclusion

Our study advances the understanding of the link between board of directors, IT investment, and its return. In particular, we examine the impacts directors' IT professional experiences on firms' IT investment growth and firm performance. We find that firms with tech-savvy directors on board are likely to experience greater IT investment growth. Moreover, tech savvy on board may lead to superior performance measured by Tobin's Q. We further show that the results are robust to omitted variable bias. The findings highlight the importance of tech-savvy directors in driving IT investment and firm performance.

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